

Sulfur, Oxygen and Hydrogen Isotope Abundance Studies in an Area of Acid Mine Drainage.

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Acid mine drainage is recognized as a major environmental hazard. Most studies consider only the build-up of the acid, iron and sulfate, and do not consider the processes that may take place in a natural environment which will bring the conditions back to pre-disturbance levels.

We report here analytical and isotope abundance studies of reactions occurring before, during and following mineral sands mining from pyrite-bearing beds. Mining and wet-milling is by a floating dredge, with mineral slurry fed through clusters of spirals for mineral separation.

Pre-mining pH and soluble iron both increase with depth below the water table and lie, respectively, in the ranges of 4.5 to 6 and 2 ppm to 20 ppm. Pre-mining sulfate is typically in the range of 3 to 10 ppm. Typical dredge pond sulfate and pH values lie in the region of 100-200 ppm and 4.0 to 5.6 respectively. Because the iron has been oxidised to Fe(III), it is found in the pond as films or as a fine, organic-rich sludge. Iron levels in the dredge pond waters are generally less than 1 ppm. Some three years after mining, groundwater iron rises to a median value of 95 ppm, with some values in excess of 250 ppm. Sulfate levels are marginally above those in the dredge pond and the pH is 5.0 to 5.4. The half-life for reduction of soluble iron and sulfate concentrations from peak values is about 3.5 years.

$\delta^2\text{H}$ and $\delta^{18}\text{O}$ determinations show the groundwater to be of meteoric origin. Sea spray is the principal source of sulfate. $\delta^{34}\text{S}$ values for pre-mining sulfate vary about + 20 ‰. Isolated pyrite sulfur is shown to have a value of -5 ‰. Sulfate sulfur obtained while iron levels are rising approximate + 5 ‰. The $\delta^{34}\text{S}$ of samples collected after sulfate has been reduced by 80 % has an average value of + 40 ‰.

These isotope values confirm the proposed reaction pathways. Pyrite is oxidised during mineral separation in the spirals and in the dredge pond. There and subsequently, Fe(III) will, with bacterial assistance, oxidise organic matter present and be reduced to soluble Fe(II) - giving rise to high soluble iron levels in the groundwaters. The pH is controlled at this time by the CO_2 produced and by clay buffering. Immediately post-mining, sulfate is little affected and remains close to pond concentrations. Eventually, sulfate-reducing bacteria generate H_2S sufficient to produce insoluble iron sulfides and reduce sulfate levels.